Otter (*Lutra lutra*) mortality and road bridge design in Loch Lomond and The Trossachs National Park

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ABSTRACT

Whilst otter (*Lutra lutra*) numbers are recovering across the UK, otters still face many avoidable risks, predominantly from road traffic accidents. A stretch of the A82, lying within the boundaries of Loch Lomond and The Trossachs National Park, was surveyed to assess both the usage of bridges across water courses, and the suitability of these bridges in providing safe passage for otters. This information was compared with existing otter road mortality data. A relationship between the sites where otter signs were found and the suitability of bridges as safe passages for otters was revealed. Otter mortalities occurred most frequently at or within 50 metres of the nearest water body. Whilst remediation would serve a valuable function in reducing otter road mortalities, it is unlikely to be able to prevent all fatal incidents from occurring. Designs of all new roads and bridges in the National Park should however include elements to allow for the unhindered and safe passage of otters and other wildlife.

INTRODUCTION

The Eurasian otter (*Lutra lutra*) population is currently recovering after a major decline during the latter half of the 20th Century (Chanin, 2006). The decline occurred when hunting and trapping of otters was common, however it is thought that the introduction of organochlorine groups of insecticides played a more major role in otter decline through the contamination of food webs (Chanin & Jefferies, 1978). Now in the early 21st century with a ban on hunting, a reduction in use of pesticides (Philcox *et al.*, 1999), and improvements in water quality and fish stocks, otter populations in the UK are no longer limited and are now recovering (Strachan, 2007). Otters still face many lesser threats which hinder their full recovery (Chanin, 2006). These potential threats include pollution, habitat destruction and disturbance as well as accidental deaths through road traffic accidents (RTAs) and fishing (Anon., 1992).

Road deaths are the primary cause of non-natural otter mortality (Green, 1991; Chanin, 2006). Road networks are expanding, motor vehicles are faster and roads are busier than they have been historically. With these trends continuing otter mortality increases (Chanin, 2006). Within the road network, trunk roads are disproportionably responsible for otter road mortalities. In the UK, these roads account for 57% of otter RTAs whilst only covering 13% of the road network (Philcox *et al.*, 1999). In Scotland, trunk roads make up a smaller proportion of the road network than in the whole of the UK or England. However, since the early 1980s these roads have accounted for around 75% of reported otter deaths (Green, 2008). Motorways account for few deaths despite the speed of the traffic, possibly due both to the failure to report accidents as motorists are unable to stop, and also the potentially increased rate at which corpses are destroyed.

Otters are particularly vulnerable to road accidents when roads run close to water bodies with 67% of all otter road mortalities occurring within 100m of fresh or coastal waterbodies (Philcox *et al.*, 1999). During periods of high rainfall and floods otters may be forced to cross roads which they wouldn't normally have to do, due to their normal routes being obstructed (Chanin, 2006). This is true of roads running parallel to rivers and not just of those roads which cross rivers (Philcox *et al.*, 1999). There is a male bias in the number of otters killed on roads. This could be linked to their larger home ranges and possibly to their bolder behaviour compared with that of females (Philcox *et al.*, 1999). It is also worth noting that otters are regularly observed to cross roads even if there is a safer alternative route (Chanin, 2006). Previous research in marine areas of Loch Lomond and The Trossachs National Park has shown that there are fewer signs of otters near 'A' roads compared with 'B' roads or areas with no roads (McMahon & McCafferty, 2006).

The Loch Lomond and The Trossachs National Park (LL&TNP) was formed as Scotland's first national park in 2002. As such it is important to monitor the human impacts on habitats and species within the park (McCafferty 2004). As river dwelling otters live at low densities and are predominantly nocturnal, unobtrusive and trap-shy, it is hard to study their habitat use and behaviour (Durbin, 1993). The A82 which runs up the west coast of Loch Lomond is expected to have an impact on the local otter population (McCafferty, 2005a). The aim of this study was to determine the current distribution of otters along the A82 and to assess the suitability of the current road for allowing safe otter movement.

METHODS

Bridge suitability and usage by otters

Eighteen sampling sites were chosen where watercourses passed under the A82. Not all the watercourses along the A82 were covered in the survey due to restriction in the survey time available. The sites were spread along the length of the A82 from the south end of Loch Lomond to Crianlarich (Fig. 1). The sites were selected to cover a variety of different sized water courses which were practical to sample. The maximum width of the watercourses ranged from just less than a metre to just over 30 metres. Each site was visited fortnightly for 10 weeks from the 2nd of May until the 11th of July 2007. On the first visit any otter signs (spraints or footprints) were removed but not recorded as the timescale for their deposition was unclear. For the remaining five visits all information was recorded.

The sampling method used was similar to that of McMahon & McCafferty (2006). Otter spraints and tracks were looked for in 100 metre sampling areas. Ideally these included the 25 metres above and below the bridges on each bank. However due to differing morphology of the sites this was not always possible and if one part of the search area was not practical to sample, the distance was added on to another part of the search area at the site. Any spraints found were collected and tracks were recorded and then rubbed away to avoid repeat measurements on future trips.

At each of the sampling sites the bridge on which the A82 crossed the watercourse was examined. Characteristics which were thought to relate to suitability for otters were measured. These measurements were maximum river width, minimum bank width and maximum river depth (m). Any obstructions which were thought to contribute to bridge suitability were noted for individual cases. Bridges were then categorised into three groups; those with obstructions and no permanent bank, those without obstructions and no permanent bank, and finally those with a permanent bank. Bank state was characterised using the high water line. Using Minitab (version 15.1), bridge characteristics (Table 1) which had been recorded were tested against the presence or absence of otters using a Mann Whitney two sample test. Secondly bridges with and without obstructions were tested against other bridge characteristics also using a Mann Whitney two sample test.

Mortalities

Information on otter road mortalities was received and collated from records held by the LL&TNP Otter Monitoring Group and from data held by Rosemary Green. This included 62 otter mortality records Identified individuals consisted of 19 males, 25 females, of which 33 adults were recorded and 18 juveniles. This information was used to plot a map of deaths in LL&TNP area (Fig. 2). The data set contained information on year, month, age, sex and location of the mortalities. However not all mortalities recorded had a complete set of information. The sample size and categories for each characteristic is shown in Table 2. The distance to the nearest water body for each mortality way measured using 1:50,000 Ordnance Survey maps.

Changes in the number of mortalities recorded over five year periods starting from 1982 were examined using a one sample Chi squared test. Seasonal variation (seasons as defined in Table 2) and difference in mortality between sexes were also tested using a one sample Chi squared test. The ratio of adults to juveniles killed was determined to see if it varied between sexes using a two sample Chi squared test. Mortality records were then split into two categories; those found within 100 metres from a water body, and those found further away. A 100 metre zone was chosen as it has previously been shown to account for most casualties (Philcox *et al.*, 1999). This was then examined using a one sample Chi squared test with an expected 1:1 distribution of mortalities on either side of 100m. Mann Whitney tests were used to see if there was a difference in the distance from water bodies where mortalities occurred firstly, between males and females, and secondly between adults and juveniles.

Fig. 1. Locations of bridge sampling sites surveyed on the A82 at Loch Lomond.

Fig. 2. Locations of otter road mortalities in the Loch Lomond and The Trossachs National Park. Points numbered 1 and 2 are estimated from incomplete grid references and general descriptions.

RESULTS

Bridge suitability and usage by otters

There were no significant differences in river width ($W_{(1)}$=58, p=0.492), river depth ($W_{(1)}$=50, p=1.042) and bank width ($W_{(1)}$=63, p=0.220) between sites with either the presence or the absence of otter signs (Fig. 3.). Bridge suitability (as described in Table 1) was found to have a significant effect on the presence or absence of otter signs ($W_{(1)}$=73, p=0.016). Otter signs were detected at around half the bridges which had a permanent bank, and also at those with no major obstructions. At signs with obstructions no otter signs were ever detected. Fig. 4 displays the presence or absence of otter signs at different bridge rankings. Otter signs were found irrespective of whether or not bridges had obstructions.

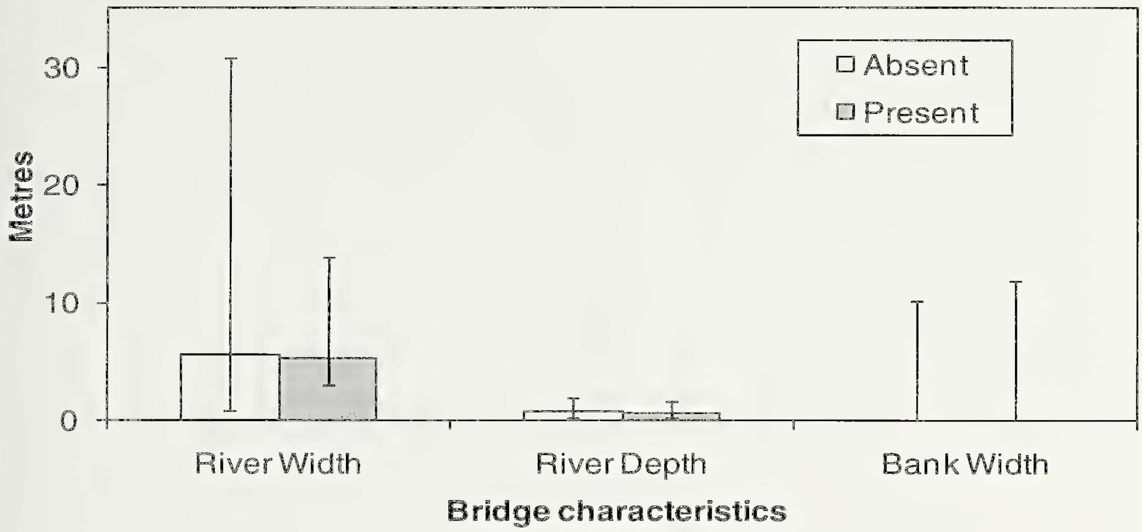

Fig. 3. Median bridge characteristics at sites with and without signs of otters (n=18). Maxima and minima are shown.

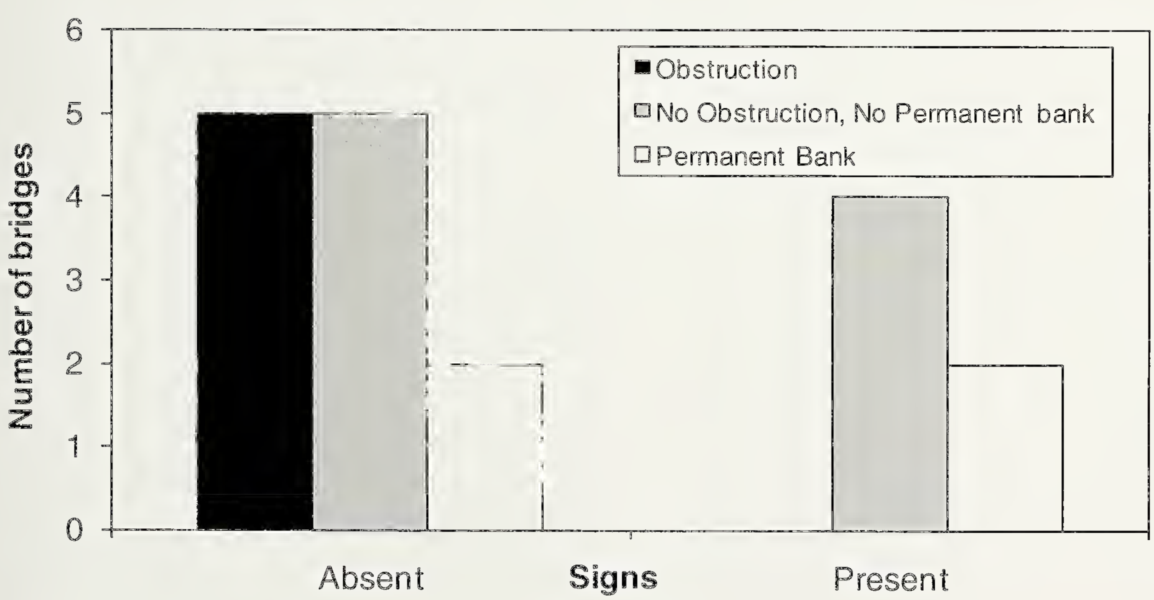

Fig. 4. The number of each bridge category at sites with and without otter signs (n=18).

Mortalities

There was no effect of year ($X^2_{(4)} = 6.32$), season ($X^2_{(3)} = 2.59$) (Fig. 5) or sex ($X^2_{(1)} = 0.82$) on the number of mortalities. In addition, there was no effect of sex on the ratio of adults to juveniles killed ($X^2_{(1)} = 0.12$) (Fig. 5).

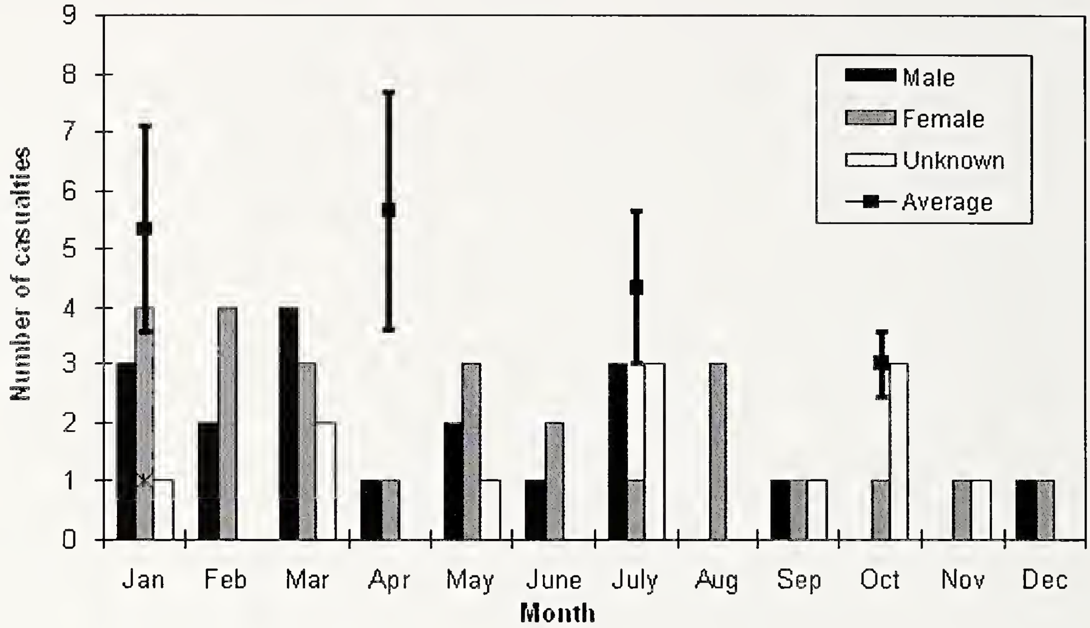

Fig. 5. The seasonal distribution of otter road casualties between 1982 and 2007. Seasonal means are shown as points with standard error bars (n=55).

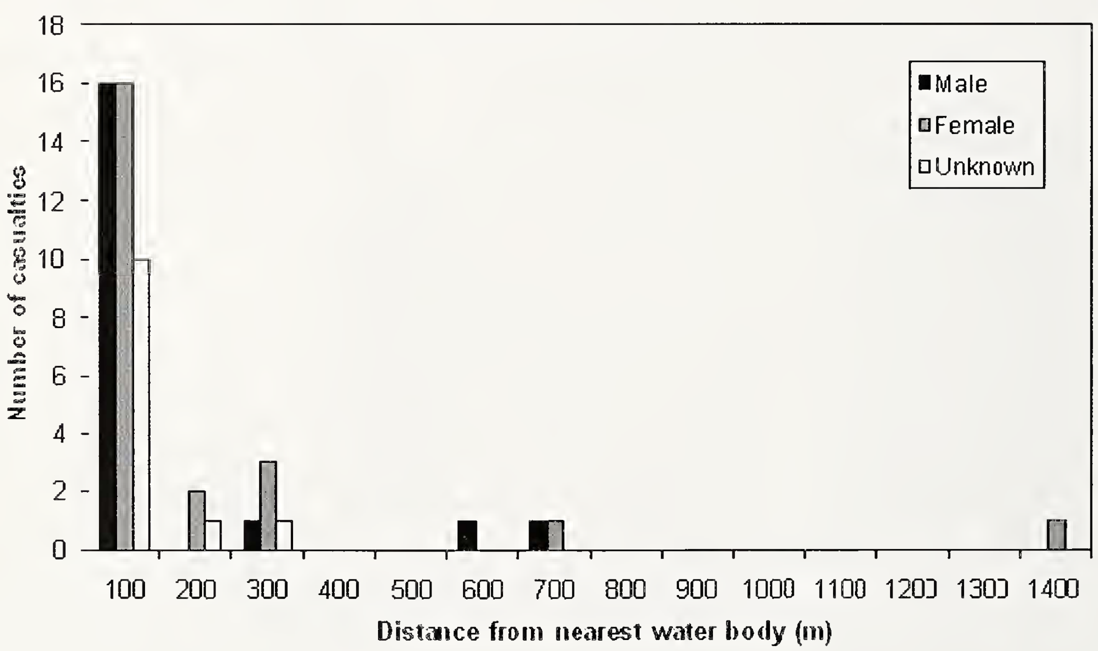

Fig. 6. Relationship between otter mortalities and distance from nearest water body (n=54).

There was found to be a significant difference ($X^2_{(1)}$= 16.67, p<0.01) in the number of mortalities that occurred within 100 metres of a water body and those at a greater distance, with 78% recorded within a 100 metre zone (Fig. 6). There was no effect of sex ($W_{(1)}$ = 402.5, p=0.771) or age category ($W_{(1)}$ = 389, p=0.6311) on the distance mortalities occurred from water.

Of the otter mortalities which occurred directly at the bridge study sites, three occurred at Site 2 (Fig. 7). Site 2 has large permanent banks, so otters do not need to cross the road. Otter signs were repeatedly found at Site 2 during the monitoring period. At Site 8, two otters were killed. The bridge at Site 8 is over 30m wide and there is a permanent bank which otters could use. Finally, one otter was killed at Site 10. The bridge at Site 10 is only 3m wide and has no permanent bank and is obstructed by several concrete ledges and wooden panels.

DISCUSSION

Even with the recent increase in otter populations otters are still relatively rare and eonserving otter populations continues to be important (Chanin, 2006). The Eurasian otter is listed as near threatened by the IUCN/WCMC and is on their red data list. Within the UK otters are a priority species in the UK Biodiversity Action Plan, and are listed under the Bern convention and the habitats directive (McCafferty, 2005a). The legislation currently in place implies an obligation to ensure the conservation of the components of the countryside that provide important habitats for otters (Kruuk *et al.*, 1998). This means that by conserving otters, their surrounding habitat will also be protected. Current conservation management schemes should be directed towards protecting habitat surrounding small streams and controlling processes which affect the composition of substrates in water bodies (Durbin, 1998).

Bridge suitability and usage by otters

Road bridges which cross wildlife corridors are often associated with detrimental impacts on local wildlife populations through habitat fragmentation and mortalities resultant from road traffic accidents (MaeDonald & Smith, 2000). This especially affects species such as mammalian carnivores which travel over large distances (Ng *et al.*, 2004). For this reason it is important to understand how otters are using existing passageways beneath bridges, and how different design features of bridges can impact on otter populations. Initially it was hoped that the fieldwork would allow for direct comparisons of frequency of otter usage between sampling sites. However the number of otter signs discovered was far lower than expected, and as a result the analysis was limited. This may be related to seasonal sprainting behaviour in the summer as otter distribution, and utilisation of stretches of water may vary seasonally (Kruuk, 1995). Whilst the presence or absence of otter signs was not related to river width, depth or bank size, overall bridge suitability did influence the oceurrence of otters. Bridge suitability was determined using two factors; firstly whether the river was unobstructed, and secondly whether the river had a permanent bank underneath the bridge. Whether or not there was a permanent bank was an approximate measure as no annual river flow information was available for the sites. Sites where otter signs occurred had a higher ranking for bridge suitability than sites where no signs of otters were found. This does not imply that there were no otters in areas where signs were absent, only that they were not leaving spraints at unsuitable bridges to the same extent.

One issue within the experimental design which may have resulted in the limited number of otter signs being detected was the small distance covered in searches. The standard sampling distance normally used in otter searches is 600m (McMahon & McCafferty, 2006, McDonald *et al.*, 2007; Strachan, 2007). Chanin (2000) highlights that there is a trade off between sampling distances and the number of sites sampled and recommends a 50m search area as a maximum. Secondly, as the summer progressed, the amount of vegetation at study sites increased. Whilst every effort was made, definitive sampling became substantially more difficult throughout the survey period.

Spraint surveys, as an indicator of otters, do have limitations. The first point which may limit spraint searches conducted in summer months is that otters are less likely to spraint on land during the summer and instead increase their level of excretions while in the water (Kruuk, 1995). This is possibly linked with the increased availability of food and a reduced need to mark resources. Previous studies have revealed that spraints last longer in dry weather than in rain or floods (Jenkins & Burrows, 1980). On several occasions the weather prior to sampling trips consisted of heavy rainfall and high water levels subsequent to periods of dry weather. This may have removed many signs of otters which had been present on the banks of the water courses. Whilst the presence of otters may be derived from the discovery of spraints, they provide no direct indication of numbers (Thom *et al.* 1998). This results from otter territories overlapping and the fact that spraints can serve both a biological function and a communication function as resource markers (Kruuk, 1995). This limitation could be overcome in future studies by radionuelide tracking methods (Kruuk, 1995), or genetic analysis of spraints (Puechmaille *et al.*, 2007).

At many of the sites, steep, near vertical artificial banks and river beds as well as blockages looked as if they had the potential to cause some difficulty to otters seeking passage. This seemed to be particularly the case for smaller streams rather than larger rivers. If these obstacles are only cutting off limited resources, then otters may reduce their usage or simply not use these stretches of water. This could be especially true when otters have easier access to equally good or even better resources in different stretches of water. However otters may prefer other areas further upstream or at different areas of Loch Lomond if there is continual disturbance in those locations where roads and water courses meet. This may particularly affect females with cubs, which may be living reclusively, far upstream, or on islands in Loch Lomond.

Mortalities

It was thought that otter road mortalities would increase with year, due to an increase in traffic as well as an increase in the proportion of deaths that were reported. This pattern has been seen in previous studies, which also noted an effect of increasing and spreading otter populations (Chanin, 2006; Green, 1991; Hauer *et al.*, 2002a; Philcox *et al.*, 1999; Strachan, 2007). The varying volume of traffic as well as the changing road conditions across different seasons has also been proposed to determine the number of road deaths throughout the year. The sex of otters was also considered as a factor which could influence road deaths, as males are wider ranging and may be more prone to audacious behaviour resulting in increased road accidents (Philcox *et al.* 1999). In this study, the number of mortalities was not significantly affected by year, season or sex. There was also no difference in the ratio of adults to juvenile mortalities between sexes. There did appear to be a slight but non-significant trend in season with fewer deaths occurring in autumn. With a larger sample size, a clearer pattern may be revealed. As the ratio of adults to juveniles in the wild was unknown, variation from this in the mortalities could not be tested for. Changes in the ratio of adults to juvenile mortalities between sexes however could be tested for; though this also tested non-significant. The mortality data did not conform to the national database. In this study more females were killed (57%) compared to 31% in the National database. Likewise 35% of mortalities were juveniles while nationally they only account for 18%. This could be a relic of the sample sizes (this study n=62, national database n= 2109) or alternatively females and juveniles may be more vulnerable in the study area.

The mean distance of otter mortalities from a mapped water body was 139m. However, the majority of otter mortalities occurred within 100 metres of a water body. This highlights that otters are in the most danger when roads run close to or across water bodies. Although young males had previously been hypothesised to be at more risk due to travelling further to seek new territories, there was no difference between the sexes or between age groups in the distance from water at which the otters were killed.

It is important to note that a lack of knowledge of otter ecology may over-emphasise the importance of these road deaths (Philcox *et al.*, 1999). As road deaths are more noticeable than natural deaths this may cause an overestimation of the proportion of deaths caused by traffic (Kruuk, 1995). There may also be an effect of increased effort in reporting and recording of otter deaths (McMahon & McCafferty, 2006).

Mortalities near sampling sites

Out of the mortalities that did occur at or near sample sites, there was no common factor in the characteristics of the road. Otters were killed on roads which they could cross under safely, on permanent banks as well as at bridges which were obstructed. There were mortalities at wide rivers and small streams, both of varying depths. Most of the deaths did appear to happen at the south end of Loch Lomond where, from observation, the A82 is wider and straighter than at the north end. This invariably leads to faster moving traffic. There may also be a difference in the volume of traffic that uses different stretches of the A82. If this is indeed the case, it could result in different stretches of the A82 having different levels of impact on otters as increasing traffic volume has been shown to negatively impact the permeability of roads for mammals (Shelley *et al.*, 2005). This also has implications for future road development, as road upgrades can potentially increase otter mortalities as has been previously observed on the A75 (Green, 2008).

Mitigation

The recent rapid expansion of road networks has the potential to block genetic exchange and to isolate small populations (Clinton *et al.*, 2005). As otters are still recovering from previous declines in populations it is particularly important to try and alleviate any negative effects the present day transport network may have. The number of otter mortalities which occur on trunk and 'A' roads is proportionally greater than on other roads (Philcox *et al.*, 1999). The probability of otters crossing a road is related to the frequency of use, and also the suitability of the bridges for allowing otters to pass underneath (Chanin, 2006). Due to cases where otters move onto roads regardless of whether they need to or not, any introduced mitigation methods may only serve to reduce rather than prevent otter road deaths. Permanent wildlife corridors under bridges would seem the most straight forward method for allowing safe passage to otters and other animals travelling along rivers. In new bridges this can be included in their design, however on existing bridges artificial passageways may need to be installed. Where room is available a ledge running along the edges of the bridge should allow wildlife safe passage. Alternatively where room is not available, tunnels could be installed beside the bridge which would allow a permanent safe passage for otters or other small animals. Otter proof fencing should not be used to block otter passage but instead help to direct otters away from roads to suitable crossing places (Philcox *et al.*, 1999). Fencing should be used carefully as it has the potential to trap otters on roads if otters cross from a different point. Signs to warn motorists may help raise driver awareness and prevent some accidents from occurring.

Obviously any mitigation strategy will incur expense. Installing new tunnels on existing roads would seem the most disruptive and costly method. Fencing and artificial ledges may initially be cheaper but will require continued monitoring and maintenance. This reinforces the importance of building new bridges with wildlife in mind, as sensible initial planning will reduce future costs. Designers of new roads should keep in mind that even if otters are not currently present, they may be in future (Philcox *et al.*, 1999; Chanin, 2006). The Highways Agency design manuals advise that new bridges should be built wide enough to incorporate a wildlife corridor and, if required, fencing to guide otters to suitable crossing points (Highways Agency, 1999). Road mitigation measures installed will not only benefit otters, but other species facing similar problems (Mata *et al.,* 2005). Any mitigation measures which are installed should be monitored to ensure that they are indeed working effectively (Lafontaine & Liles, 2002).

Monitoring spraints and tracks are the simplest and cheapest methods to identify sites where otters travel out of water (McCafferty, 2004). Spraints do not give accurate estimate of populations, however, they can be used to describe general spatial distribution (McMahon & McCafferty, 2006). Sprainting is more common in areas with wooded vegetation or dense cover (Bas *et al.*, 1984, Jenkins & Burrows 1980). As sprainting is non-random this does not necessarily reflect that otters prefer to spend time in wooded or densely vegetated areas (Kruuk, 1995).

CONCLUSION

Otter presence was confirmed at several sites along the major trunk road that runs through Loch Lomond and The Trossachs National Park. Sites where no signs of otters were discovered may still be used by otters, though possibly they remain in the water or travel on land less frequently or at different seasons. The majority of bridges at survey sites did not include permanent wildlife corridors, and several bridges had obstacles which could potentially obstruct safe passage underneath roads. The frequency of otter mortalities decreased with increasing distance from the nearest water body. Several otters were killed at sites where safe, unobstructed passages were available beneath bridges. It is suggested that road mitigation measures are developed to reduce otter mortality on major trunk roads such as the A82 in the National Park.

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APPENDIX

Characteristic	Sample size	Information
Bridge rating	18	Category of bridge 1= obstruction, 2= no obstruction but no permanent bank, 3= permanent bank
Otter signs	18	Spraints or prints 0=signs absent 1=signs present
River width	18	River width in metres from high water marks
River depth	18	River depth in metres from level of high water flow to deepest point
Bank width	18	Width of bank under bridge in metres at high water flow
Site location	18	6 figure grid reference

Table 1. Definition and description of variables used in analysis of otter signs and bridge characteristics

Characteristic	Sample size	Information
Mortalities	62	Total number of mortalities in data set
Year	61	Year which the mortality was recorded. In analysis grouped into five year sets (the starting year for each of the sets were 1982, 1987,1992,1997,2002)
Season	55	Season in which the mortality was recorded. Seasons defined as; Spring – March-May; Summer – June-August; Autumn – September-November; Winter – December-February
Sex	44	Male or Female
Age	51	Adult or Juvenile
Nearest water body	54	Distance in metres to the nearest loch or river from sites which have an associated 6 figure grid references
Site location	54	6 figure grid reference

Table 2. Definition and description of variables used in analysis of mortality data set

Site	Grid Reference	Maximum channel width (m)	Maximum depth (m)	Minimum bank width (m)	Signs
1	NS 373833	3.00	0.17	0.00	Yes
2	NS 356857	13.90	1.68	11.90	Yes
3	NS 353867	3.00	0.39	0.00	Yes
4	NS 353881	9.15	0.62	0.00	No
5	NS 356895	3.04	0.96	0.00	No
6	NS 357926	21.10	1.96	10.23	No
7	NS 353955	1.74	0.27	0.00	No
8	NS 346980	30.78	1.34	0.35	No
9	NS 343993	3.00	0.45	0.00	No
10	NN 337007	3.00	0.88	0.00	No
11	NN 321046	4.35	0.70	0.00	No
12	NN 321149	10.19	0.45	0.17	Yes
13	NN 318158	0.91	0.17	0.00	No
14	NN 315167	6.00	0.72	0.00	Yes
15	NN 317184	6.95	1.00	0.00	No
16	NN 319198	13.75	0.97	0.00	No
17	NN 333207	4.50	0.87	0.00	Yes
18	NN 347219	6.90	0.41	0.00	No

Table 3. Sampling site information.

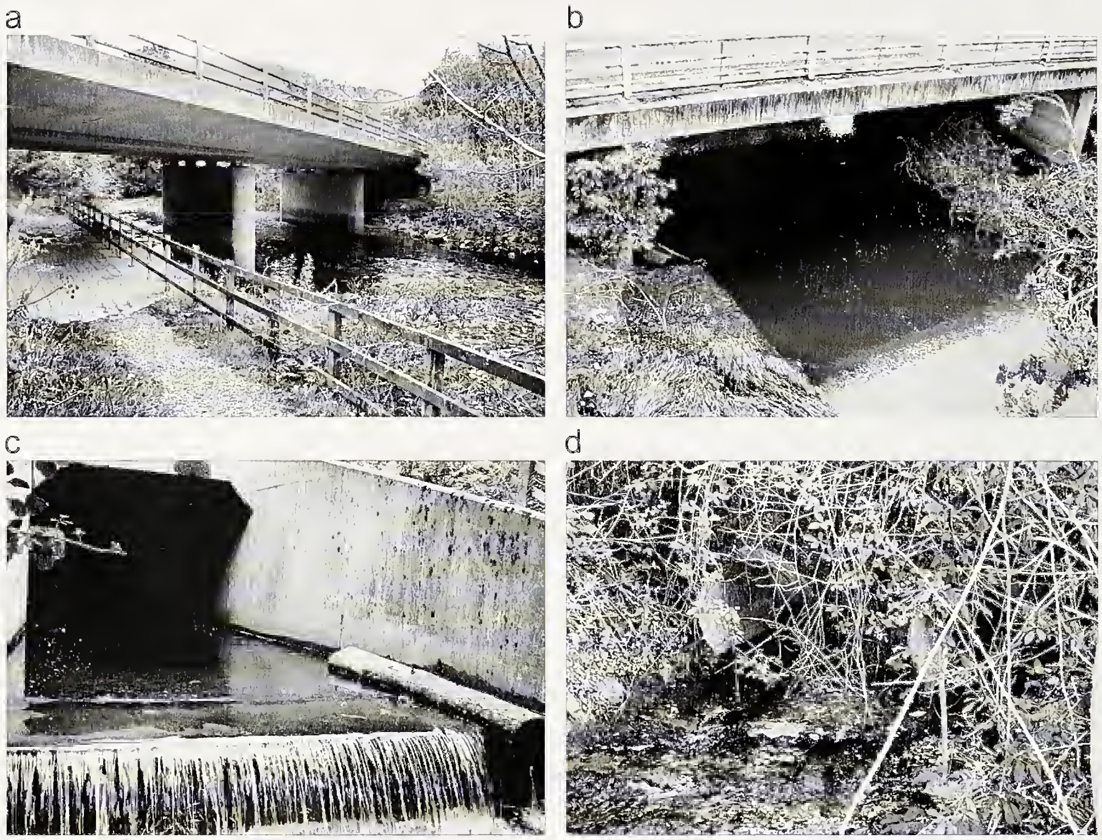

Fig. 7. Bridges with permanent bank allowing continual passage for otters and other wildlife (a): site b (NS357926) and (b): site 2 (NS356857). Bridge with no permanent bank and large concrete obstruction, potentially blocking otter passage (c): site 5 (NS356895). Culvert under bridge consisting of two concrete pipes that could prevent otter passage depending on water levels (d): site 7 (NS353955).